288,664
51,009/64

COMMONWEALTH OF AUSTRALIA

PATENT SPECIFICATION

		Class	Int. Cl.
Application Number	51,009/64.	40.7; 60.2.	D02d; F16h;
Lodged	28th October, 1964.	60.3.	F06h.
	Accompanied by a Provisional Specification.		
Complete Specification Entitled	TWISTING APPARATUS.		

Lodged 25th October, 1965.
Accepted 14th January, 1969.
Published 27th April, 1967.

Convention Priority -

Applicant COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION.

Actual Inventor GORDON WILLIAM WALLS.

Related Art:

260,092(10,441/64)	40.7.
216,019(15,968/56)	40.7. 40.5.
206,880(15,428/56)	40.7.

The following statement is a full description of this invention, including the best method of performing it known to us :

103-5D-27/2/69-15P.C.
Printed for the Government of the Commonwealth by A. J. Arthur, Commonwealth Government Printer, Canberra

This invention relates to apparatus for forming twisted textile strands having alternating zones of opposite twist.

The apparatus has been designed particularly for the production of stable twisted assemblies by the process described in our prior Australian Patent No. 260,092.

In our said prior Australian Patent No. 260,092 there are described a number of methods and apparatus for producing alternating twists in a textile strand, but we have found that these methods all suffer from certain disadvantages either in relation to their potential production rate, the strength and weight per unit length of yarn which can be handled or in relation to the maintenance of twisting efficiency. Of these previously described methods, that most extensively used in our experimental work was that using the twisting discs but this method suffers from the major disadvantage that as the strand is pulled between the discs there is relative motion between the discs and the strands in the direction of motion of the yarn. This imposes a tension on the strand and results in a serious limitation on the weight per unit length of the strand being processed. It also results in wear in the elastomeric surface of the discs so that regular adjustment of the discs and replacement of the elastomeric surfaces is necessary to maintain efficient twisting. Other twisting techniques such as those using twisting tubes also require relative motion between the strand and the twisting surfaces and lead to similar difficulties. Further systems using crossing belts and hyperboloidal rollers have the defect that it is difficult or impossible to maintain the strand in the most efficient twisting position relative to the twisting surfaces.

The object of this invention is therefore to provide a novel apparatus which is capable of very high production rates in which the twisting efficiency can be maintained and with which finer yarns can be produced.

According to this invention there is provided apparatus for twisting a travelling strand comprising a pair of forwardly moving transversely reciprocating twisting surfaces arranged to form a nip between them and to reciprocate in opposite phase and means to supply the strand to the nip whereby alternating zones of opposite twist are imparted to the strand as it passes through the nip.

Preferably, in order to ensure adequate twist intensity the oscillation of the twisting surfaces is such that the ratio of the amplitude of the reciprocation to the twist zone length is not less than 0.6 and preferably also its ratio to the mean diameter of the twisted strand is not less than 80. Preferably also, the apparatus is adapted simultaneously to twist a pair of strands. More particularly, the twisting surfaces comprise a pair of oppositely rotated transversely reciprocating rollers.

According to a further aspect of the invention there is provided apparatus for forming stable twisted threads comprising a pair of forwardly moving transversely reciprocating twisting surfaces arranged to nip the strand between them and to reciprocate in opposite phase, means to supply a strand to the nip whereby alternating zones of opposite twist are imparted to the strand as it passes through the nip and means to converge the strand with another strand, said convergence means being spaced, in the direction of travel of the strand, a distance not more than the length of a twist zone from the position at which the stand was

last contacted by the twisting surfaces. Preferably this distance is not more than one fifth of the twist length. Preferably the forward velocities of the twisting surfaces at the nip position are substantially equal to the forward speed of the strand.

There are many alternative forms of drive which may be used to reciprocate and rotate the twisting surfaces. A simple arrangement which may be employed to reciprocate and rotate the twisting rollers comprises a crank mechanism for reciprocating the rollers along rotating shafts. For simple synchronisation of the reciprocation of the rollers, the crank may be arranged to oscillate a disc or centrally pivoted arm to opposite sides of which the rollers are connected through flexible links, such as bands, chains or the like.

In an alternative form of drive, the rollers may be reciprocated by means of an epicyclic drive comprising a fixed gear and a planetary pinion which is rotated about the axis of the gear, wherein the pinion is rotated about its own axis at a speed twice that of its rotation about the axis of the gear but in the opposite sense and wherein the roller is pivotally connected to the said pinion about a pivot axis passing through a point displaced from the axis of rotation of the pinion a distance equal to the distance between the axis of the gear and the axis of the pinion. Preferably there is also provided a gear which is fixed to the pinion for rotation with it and having its axis on the said pivot axis, whereby the roller may be rotated. A simple form of such a drive comprises an internal planetary pinion which is of pitch circle diameter half that of an internally toothed fixed gear and in which the roller to be reciprocated is pivotally connected to the pinion about an axis lying on the normal projection

of its pitch circle.

Throughout this specification reference is made to the "nip" of the twisting surfaces. In current textile terminology the word "nip" is frequently understood to imply that the rollers or like elements which form the nip actually contact one another at the nip position. In this specification, it is to be understood that no such limitation is intended and that the expression "nip" is used to include not only the case where the surfaces are touching, but also the case where the surfaces each contact the strand which is between them but do not contact one another.

In order that the invention may be more readily understood, it will now be more fully described with reference to the accompanying diagrammatic sketches which illustrate exemplary embodiments of it.

Figure 1 shows diagrammatically a perspective view of an apparatus embodying this invention;

Figure 2 is a front elevation of one form of apparatus in accordance with the invention employing a crank drive for reciprocating twisting rollers;

Figure 3 is an end elevation viewed from the line 3-3 in Figure 2;

Figure 4 is a cross-section on the line 4-4 in Figure 2;

Figure 5 is a longitudinal cross-section of the twisting rollers shown in Figure 2 showing the means of mounting them on their shafts;

Figure 6 is a cross-section on the line 6-6 in Figure 5;

Figure 7 is a front elevation of a pair of twisting rollers having an epicyclic drive;

Figure 8 is a plan view of the apparatus shown in Figure 7;

Figure 9 is an enlarged cross-section of one of the epicyclic drive units shown in Figure 7;

Figure 10 is a cross-section on the line 10-10 in Figure 9;

Figure 11 is a perspective view on a slightly smaller scale of the main driving gear and crank assembly of the mechanism shown in Figure 9;

Figure 12 is a perspective view of the planetary pinion and its associated shaft of the mechanism shown in Figure 9;

Figures 13 to 19 are schematic plan views of the epicyclic drive showing various stages in the simultaneous reciprocation and rotation of a roller connected to the mechanism;

Figure 20 is a view partly in cross-section (illustrating one roller only) of another form of apparatus using an epicyclic drive, but in which the roller is supported and guided in an air bearing; and,

Figures 21 to 27 are views similar to Figures 13 to 19 showing schematically an alternative form of epicyclic drive in which an externally toothed gear is used.

Referring now to Figure 1 a strand 5 emerges from the nip of a drafting mechanism 6 positioned close to a pair of rubber covered rollers 7, 8 arranged so that they are just touching or with a small gap between them. These rollers are driven so that they reciprocate in opposite phase and rotate in opposite directions so that their adjacent surfaces move in the direction in which the strand 5 is fed forwardly by the drafting mechanism and at substantially the same speed. A strand leaving the drafting mechanism enters the nip of the rollers 7, 8 and due to the transverse reciprocation of these rollers

the travelling strand is twisted so that as it passes from the nip it has alternating zones of opposite twist. The strand 5 so twisted is, in accordance with the process of our Australian Patent

, converged by means of a convergence guide 9 with another strand 5'. This convergence guide 9 is placed as close as possible to the nip of the oscillating rollers 7, 8 so as to preserve as much as possible of the twist inserted by the rollers as the strand passes between them. After the converged strands leave the convergence guide, they travel over a substantially free length to a traversing guide 9' and thence to a take-up package 10. This free length is chosen so as to allow an ample distance over which the converged strands can twist about one another to form a stable twisted assembly as is more fully described in our aforesaid prior Australian Patent No. 260,092. The free length should be at least the length of a twist zone.

There are a number of ways in which the reciprocating rollers can be reciprocated and simultaneously rotated. One way in which this can be done is illustrated in Figures 2 to 6. In the apparatus shown in Figure 2 the rollers 7, 8 are mounted on shafts 11, 12 which are rotated in opposite directions through a gear drive 13 from an input belt drive 14. In order to allow them to rotate with the shafts and at the same time to be reciprocated the rollers are keyed to their shafts by feather keys 15, which are free to slide in long keyways 16 so as to allow relative sliding movement between the rollers and the shafts. Each roller is engaged by a yoke 17, 18 in such a way that relative rotation between the roller and the yoke can occur but no relative translation is permitted. These yokes are

connected by means of belts, bands, chains or the like 19, 20 to wheels 21, 22 one of which (21) is caused to reciprocate by means of a crank 23 and connecting rod 24 driven through belt drive 25. The yokes are thus caused to reciprocate on their guides 26, 27 and thereby to reciprocate the rollers as they are simultaneously rotated by the gear drive 13. This form of drive is relatively simple and has the advantage that by adjustment of the geometry of the crank drive a complex harmonic reciprocating motion can be produced to produce a desired twist intensity distribution in a strand being twisted. It will be appreciated also that the actual drive system may be varied. For example the shafts may be made to reciprocate in the drive gears which would then be feather-keyed to the shafts. In another alternative, the shafts may be hollow and the rollers reciprocated on the shafts by means of lugs projecting through slots in the shafts and reciprocated by means of a reciprocating chain or the like positioned within the shaft. This latter construction would have the advantage that the large reciprocating sliding mass of the yokes is eliminated.

In the illustration shown two pairs of strands 5, 5' and 5a, 5a' are being processed simultaneously. These pairs of strands are converged after twisting to form a self-twist structure in the manner previously described with reference to Figure 1.

The above described apparatus whilst it is relatively simple has the practical disadvantage that it involves a large amount of sliding friction. In a more advanced form of apparatus shown in Figures 7 to 19, each roller is driven by means of an epicyclic gear train of a type which is shown in detail in Figures 9 to 12.

Figures 7 and 8 show the two rollers 7, 8 supported at either end by epicyclic driving pots 30, 31, 32, 33, each of which are driven in synchronism by their respective input drive gears 30', 31', 32' and 33'. The pots incorporate an epicyclic train in which a crank mounted epicyclic pinion is driven about a fixed gear. With this mechanism, it is known that provided the diameter of the pinion is half the diameter of the wheel a point on the pitch circle of the pinion or on the normal projection of that pitch circle will reciprocate in a straight line. The known mechanism is however modified in that at such a point, there is incorporated a spindle upon which is mounted a gear which is fixed relative to the pinion and which therefore executes a rotation about an axis parallel to the axis of the pinion as the said point reciprocates. This rotation is used to rotate the rollers.

The construction of one of the pots 30, 31 is shown in detail in Figures 9 to 12. Each such pot comprises a housing 34 in which is mounted an internally toothed ring gear 35 secured by screws 36 to the housing. The housing also carries within it a main drive and crank assembly 37 which is rotatably mounted about an axis concentric with that of the ring gear by means of bearings 38, 39.

As shown in Figure 11, the assembly 37 comprises a main driving gear 40, a shaft 41 and a body portion 42. The body portion itself forms a housing for spindle 43 which is rotatably mounted in the housing by means of bearings 44, 45 and which carries at its lower end a pinion 46. The pinion 46 meshes with the ring gear 35 and is of pitch circle diameter half that of the ring gear.

As shown in Figure 12, the spindle 43 carries at its upper end a crank and counterweight block 47 and a hole 48 is bored in the

crank. This hole in turn houses a bevel gear 49 which is secured to crank 47 by means of a pin 50. The hole 48 is positioned so that the axis of rotation of the bevel gear 49 lies in a normal projection of a point on the pitch circle of the pinion 46.

The bevel gear is hollow and carries within it, by means of bearings 51, 52, a spindle 53. This spindle in turn carries a yoke 54 which supports, by means of bearings 55, 56, the horizontal shaft 11 of the roller 7. The shaft 11 has a bevel pinion 57 secured to it and this meshes with the bevel gear 49.

The operation of the train is as follows :-

The drive gear 30' drives the gear 40 and therefore rotates the main spindle 41 of the crank assembly 37. This causes the crank to rotate and thereby to rotate the pinion 46 around the ring gear 35. The spindle 43 is therefore rotated thereby rotating the crank 47 and its associated bevel gear 49. Since the spindle 53 has its axis on the projection of the pitch circle of the pinion 46, it will reciprocate in a straight line thereby causing the roller 7 to reciprocate. Thus we have provided a drive which will simultaneously reciprocate and rotate the roller 7. The pot 31 is identical with the pot 30 and accordingly the roller 8 is similarly rotated and reciprocated, but the drives are arranged so that its reciprocation is in opposite phase to that of roller 7.

Referring now to Figures 7 and 8, it will be observed that the opposite ends of the rollers are carried by pots 32, 33. These pots contain mechanisms similar to the driving mechanisms. These mechanisms, however, differ from the driving mechanisms in that the bevel gears are not provided and the shafts are simply journalled

in ball bearings 60 housed in the yokes 61, 62. Due to the fact that the yokes, and therefore the bearings, are carried by spindles mounted on cranks connected to epicyclic pinions in the same manner as the yokes 54, these bearings will reciprocate. Because of this the arrangement is such that there is no sliding bearing in any part of the mechanism and this greatly facilitates lubrication.

A further advantage of the above-described construction is that since the rollers are reciprocated in a straight line by means of two oppositely rotating elements it becomes possible to balance their mass with balancing masses attached to those elements. This balancing has been effected simply by providing a balancing mass 65 mounted on the flange 66 of the body 42 and the counterbalance mass 67 on the crank 47.

For the purpose of simple explanation, the actual position of the elements in the epicyclic drive are shown diagrammatically in Figures 13 to 19 at various stages during one complete reciprocation of a roller.

Figure 13 shows the roller at one extreme position. In the position shown in Figure 14, the main crank assembly 37 has rotated one eighth of a turn in anti-clockwise direction and the pinion crank assembly 47 has rotated one eighth of a turn in the clockwise direction. Likewise the bevel gear 49 has rotated one eighth of a turn in the clockwise direction relative to the pinion 57 on the shaft 11 and that shaft has commenced to move across to the left. It will be apparent that the actual amount of rotation of the shaft 11 due to the relative rotation of the bevel gear 49 and the pinion 57 will depend upon the ratio between the gear and the pinion.

Figure 15 shows the position of the elements when the main crank assembly 37 has completed a quarter of a turn; Figure 16 shows them in the position after 3/8ths of a turn, and Figure 17 after half a turn with the shaft 11 to the extreme left. Figure 18 shows the position after 5/8ths of a turn and Figure 19 shows the position after 7/8ths of a turn. The next position, after a full turn, of course corresponds to that shown in Figure 13.

Observation of Figures 13 to 19 will also show the effect of the balancing masses 65 and 67. In Figure 13 the shaft 11 is momentarily stationary at the outer end of its stroke so that it is in a position of maximum acceleration with the out of balance force acting outwardly to the right. It will be observed that in this position the centrifugal forces exerted by the contra-rotating masses 65 and 66 will be coincident and to the left exactly opposite to the acceleration forces acting on the shaft 11. The masses are such that in operation their centrifugal forces are of equal magnitude. In Figure 15 the shaft is in the middle of its stroke so that it is at its position of maximum velocity and zero acceleration. There is therefore no out of balance force acting on the shaft and the balancing masses 65 and 67 are seen to be acting in opposition at right angles to the axis of the shaft. Figure 17 shows condition of the cranks displaced 180° from that of Figure 13 with the shaft 11 once again at a position of maximum acceleration and with the forces exerted by the balancing masses again being coincident and opposite to the force exerted by the acceleration of the shaft 11. Thus, it will be seen that the balancing masses 67, 65 provide complete balancing of the mass of the roller and the shaft 11 in the vertical plane. There is, of course,

an out of balance couple due to the displacement of the centre line of the shaft 11 from the centre of action of the two rotating balancing masses. This out of balance couple is however of negligible magnitude compared with the acceleration forces acting on the shaft.

In Figures 21 to 26 there is shown diagrammatically an epicyclic drive in which the fixed gear 68 is externally toothed and the pinion 69 is rotated clockwise about it by means of a crank 70. The ratio of the gear to the pinion is two to one as in the previous case, but an intermediate gear 71 is interposed to reverse the direction of rotation of the pinion. Connected to the pinion is a connecting link 72 and a roller to be reciprocated is pivotally connected to this link at a point 73 which is displaced from the centre 74 of the pinion a distance equal to the distance between the centre of the pinion and the centre 75 of the gear. As will be seen from the diagrams, rotation of the crank in a clockwise direction will cause the pinion to rotate in an anti-clockwise direction and the point 73 will move in a straight line passing through the centre 75 of the gear 68.

One of the advantages of the drive illustrated in Figures 21 to 26 is that it can be designed to give virtually any desired stroke and this stroke is equal to four times the distance between the centres 74, 75. With the gear train shown, the stroke is a very long one, but if the intermediate gearing were arranged such that the pinion overlapped the gear and its centre were close to that of the gear a very short stroke could be achieved. It will be appreciated also that if the intermediate gear is a compound gear the diametral ratio of the gear and the pinion will not be two to one, but whatever ratio is required to give an overall speed ratio of two to one between them.

One of the principal practical problems which has been encountered in the operation of apparatus in accordance with this invention is that the spacing between the twisting rollers must be accurately controlled if the best results are to be obtained. This spacing should not be more than half the mean diameter of the strand. The twisting rollers which appear to be most suitable are rollers covered with a hard abrasion resistant anti-static synthetic rubber. We have found that using these rollers, for the production of fine yarns (up to about 22 tex strands) more consistently uniform yarn is obtained when the gap between the twisting surfaces is maintained to very close tolerances. Preferably the gap should be maintained to be less than 0.001", and preferably also, the rollers should not be in contact, so that rubbing between the rollers is avoided. Rubbing between the rollers can result in abrasion and heating of the twisting surfaces.

It is to be understood that the method can be used with gaps between the twisting rollers greater than 0.001", and that also such a mechanism can be used when the rollers are in contact. However, it will be realised that the greater the accuracy with which the gap can be maintained, the more consistent will be the properties of the yarn produced. In order to achieve the desired accuracy, it is presently proposed to use aero-static (externally pressurised air) bearings to support and guide the reciprocating shafts.

A diagrammatic view of a roller supported in such bearings is shown in Figure 20. The roller 7 in this case is supported on a lightweight hollow shaft 76 to reduce the reciprocating mass and is supported at each end in air bearings 77, 78. The drive is from a

single epicyclic pot 30 of the type previously described and to allow for slight misalignment of the drive, the output shaft 79 of the pot is connected to the roller by means of a flexible coupling comprising a rubber bush 80. The air bearings are of conventional type in which bearing jets 81 are fed from a manifold 82 which is supplied with air at approximately 60 p.s.i.g. through a supply pipe 83. In order to prevent exhaust air from the bearing from blowing along the shaft towards the rollers, exhaust spaces 84 are provided at the inner end of the bearings through which the air may be exhausted.

In Figure 20, the drive to the roller is shown to be of the epicyclic type. It is believed that this form of drive will be the most suitable, but of course, other drives such as those illustrated and described with reference to Figures 2 to 6 could be used. Similarly it will be realized that other types of bearing can be used with the epicyclic pot drive.

In the diagrams, the convergence guide means 9 is shown to be a simple U-shaped guide of the intersecting type. It is to be understood however, that other forms of convergence means may be used and if a predetermined phase relationship is required in the yarn structure, the guide may be such as to provide an extended path for one of the components of the structure as is described in our prior Australian Patent. No. 260,092 There are of course other ways in which phasing of strands may be effected. One way, for example, is to employ two twisting mechanisms operating in the desired phase relationship and feeding to common points.

Apparatus constructed in accordance with this invention

possesses many advantages over existing apparatus. As previously mentioned it possesses the very important advantage that operation can be carried out in such a way there is no relative motion between the periphery of the strand and the twisting surfaces. This factor permits the production of fine yarns by reducing the danger of end breaks in the system. Further advantages of the constructions according to this invention are that those using the epicyclic drive can be balanced and can be operated at very high speeds and having regard to the fact that one unit can produce several strands side by side they are very compact both in the transverse direction and in the direction of travel of the strand. In relation to this latter consideration it should be noted that with the construction above described in which the strand is twisted alternatively rather than intermittently, as in the case of the disc twisting apparatus described in our aforesaid prior Australian Patent No. 260,092, the twisting distance, i.e. the distance between the twisting surfaces and the output of the drafting mechanism can be made very short. As well as the advantages of compactness which follow from this, it facilitates making the machine self-threading and also enables the problem of "fly" to be greatly reduced. In actual apparatus constructed in accordance with the invention, the greater part of the apparatus where "fly" could be a problem can be enclosed and suction devices can be installed to take away loose fibres. Further advantages which derive from the use of the epicyclic drive mechanism shown in Figures 7 to 19 are that no separate drive is necessary to provide the rotation of the rollers and sliding friction in the mechanism can be eliminated.

Actual apparatus constructed in accordance with this invention and having a drive of the type shown in Figure 2 had the following dimensions :-

Drafting roller diameter - 5 cm.

Drafting roller length - 15 cm.

Reciprocating roller diameter - 3.1 cm.

Reciprocating roller length - 25 cm.

Distance between centres of drafting rollers and reciprocating roller - 4 cm.

Reciprocation amplitude - 7.5 cm.

Distance from twisting roller nip to convergence guide - 1 cm.

Distance from roller nip to take-up package - 25 cm.

Number of single strands twisted - 8.

Apparatus constructed as above was operated at a reciprocation speed of 750 reciprocations per minute with a cycle length (length of 2 successive twist zones) equal to 20 cm. at a production rate of 150 metres per minute. A similar apparatus employing the epicyclic drive of Figures 3 and 4 was operated at 1500 reciprocations per minute with a cycle length of 20 cm. and gave a production rate of 300 metres per minute.

The actual value of the physical parameters of the system for optimum operation vary according to the circumstances of the particular yarn being produced. Our investigations have shown however that for efficient twisting the amplitude of oscillation of the twisting rollers should be fairly high and its ratio to the twist zone length of a strand being twisted should not be less than about 0.6.

It has also been found that the relation between amplitude of oscillation and the mean diameter of the strand is important and should preferably be not less than 80. In the example cited above it will be seen that the ratio of amplitude to twist zone length is 0.75 and for a 20 Tex strand, the ratio of amplitude to the mean diameter of the strand would be about 390.

Using apparatus of the type described above and illustrated in Figure 2, a worsted yarn was produced using 70's quality wool consisting of two 9 tex strands. The final count of the yarn was therefore 18 tex and this yarn, after a further processing in accordance with conventional practice, was woven to form an exceptionally fine fabric weighing 84 grams per square metre.

In order to give a comparison between apparatus constructed in accordance with this invention and operating to produce self-twisting strands in accordance with the method described in our aforesaid prior Australian ~~patent~~ Patent No. 260,092 and conventional spinning machinery, the following table contrasts certain operational characteristics of a conventional machine and a self-twisting (S-T) machine constructed in accordance with this invention and operated to give a similar output.

	Conventional Spinning Machine	S-T Machine
Power Consumption	15 H.P.	2 H.P.
Floor Area	100 Sq. ft.	13 Sq. ft.
Maximum Package Weight	2 - 8 ounces	No limit
Minimum Weight per unit length with 70's wool	15 tex (two folded to yield 30 tex yarn)	10 tex (self twisted to yield 20 tex yarn)

It is to be understood that the constructions described and illustrated are purely exemplary of two forms of the invention and that many modifications may be made to the apparatus. It will be apparent, for example, that the apparatus may be made to produce yarns having alternating zones of opposite twist by causing the twisting rollers to twist the yarn intermittently. This could be achieved by, for example, relieving the twisting surface of the rollers so that during part of their stroke no twisting occurs.

The claims defining the invention are as follows:-

1. 1. Apparatus for twisting a travelling strand comprising a pair of forwardly moving transversely reciprocating twisting surfaces arranged to form a nip between them and to reciprocate in opposite phase, and means to supply the strand to the nip whereby alternating zones of opposite twist are imparted to the strand as it passes through the nip. (28th October, 1964).

2. Apparatus for forming stable twisted threads comprising a pair of forwardly moving transversely reciprocating twisting surfaces arranged to form a nip between them and to reciprocate in opposite phase, means to supply a strand to the nip whereby alternating zones of opposite twist are imparted to the strand as it passes through the nip and means to converge the strand with another strand, said convergence means being spaced, in the direction of travel of the strand, a distance not more than the length of a twist zone from the position at which the strand was last contacted by the twisting surfaces. (28th October, 1964)

3. Apparatus as claimed in claim 1 or claim 2, wherein the forward velocities of the twisting surfaces at the nip position are substantially equal to the forward speed of the strand. (28th October, 1964)

4. Apparatus as claimed in any one of the preceding claims, wherein the twisting surfaces are arranged with a gap between them and said gap is not greater than half the mean diameter of the strand to be twisted. (28th October, 1964)

5. Apparatus as claimed in any one of the preceding claims, wherein the twisting surfaces comprise a pair of oppositely rotated transversely reciprocating rollers. (28th October, 1964)

6. Apparatus as claimed in claim 5, wherein the rollers are reciprocated by means of a crank mechanism connected to the rollers by means of a pair of flexible links arranged to be reciprocated simultaneously and in opposite phase by the said crank mechanism. (28th October, 1964)

7. Apparatus as claimed in claim 5, wherein the rollers are reciprocated by means of an epicyclic drive comprising a fixed gear and a planetary pinion which is rotated about the axis of the gear, wherein the pinion is rotated about its own axis at a speed twice that of its rotation about the axis of the gear but in the opposite sense and wherein the roller is pivotally connected to the said pinion about a pivot axis passing through a point displaced from the axis of rotation of the pinion a distance equal to the distance between the axis of the gear and the axis of the pinion. (28th October, 1964)

8. Apparatus as claimed in claim 7, wherein the rollers are each rotated by means of a gear fixed to the pinion for rotation with it and having its axis on the said pivot axis. (28th October, 1964)

9. Apparatus as claimed in claim 7 or claim 8, wherein the reciprocating masses of the rollers are balanced by means contra-rotating rotary masses connected to the drive gears and to the planetary pinions. (28th October, 1964)

10. Apparatus as claimed in any one of claims 7 to 9, in which each end of each roller is connected to an epicyclic drive mechanism. (28th October, 1964)

11. Apparatus as claimed in any one of claims 7 to 10, wherein the epicyclic drive comprises an internal pinion which is of pitch circle diameter half that of an internally toothed fixed gear and in which the roller to be reciprocated is pivotally

connected to the pinion about an axis lying on the normal projection of its pitch circle. (28th October, 1964)

12. Apparatus as claimed in any one of claims 7 to 10, wherein the fixed gear is an externally toothed gear and there is an intermediate gear between the fixed gear and the planetary pinion. (25th October, 1965)

13. Apparatus as claimed in any one of claims 5 to 12, wherein the rollers are supported in air bearings. (25th October, 1965)

14. Apparatus as claimed in any one of the preceding claims, further wherein the transverse reciprocation of the twisting surfaces is such that the ratio of the amplitude of the reciprocation to the twist zone length is not less than 0.6 and its ratio to the mean diameter of the twisted stand is not less than 80. (25th October, 1965)

15. Apparatus substantially as hereinbefore described with reference to Figures 1 to 6 of the accompanying drawings. (28th October, 1964)

16. Apparatus substantially as hereinbefore described with reference to Figures 1 and 7 to 19 of the accompanying drawings. (28th October,1964)

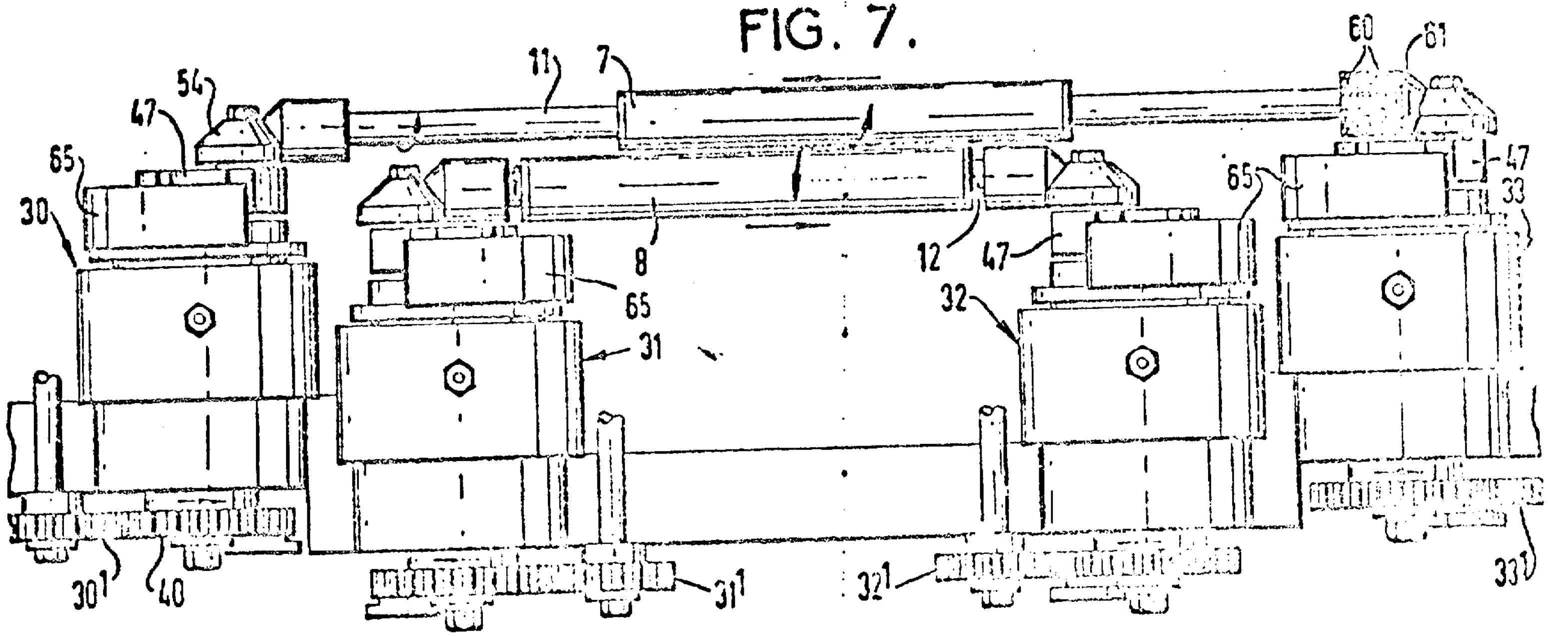
17. Apparatus substantially as hereinbefore described with reference to Figures 1 and 21 to 26 of the accompanying drawings. (25th October, 1965)

18. Apparatus substantially as hereinbefore described with reference to Figure 20 of the accompanying drawings. (25th October, 1965)

Dated this 9th day of October, 1968.

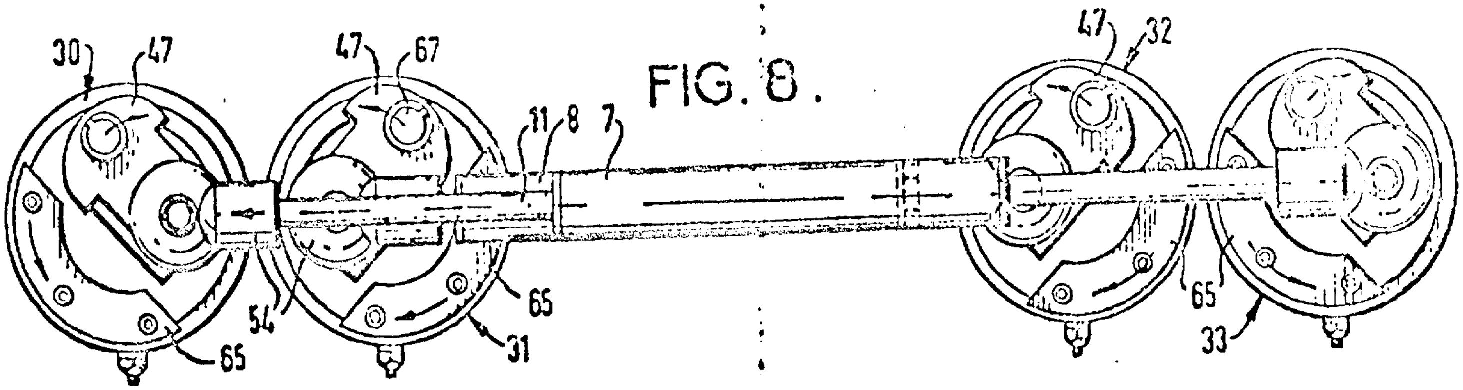
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL
RESEARCH ORGANIZATION
By its Patent Attorneys
DAVIES & COLLISON

FIG. 7.



60
61
11
7
54
47
65
30
47
33
65
8
12
47
65
31
32
30^1
40
31^1
32^1
33^1

FIG. 8.



30
47
47
67
11
8
7
47
32
54
65
31
65
65
33
65

288664

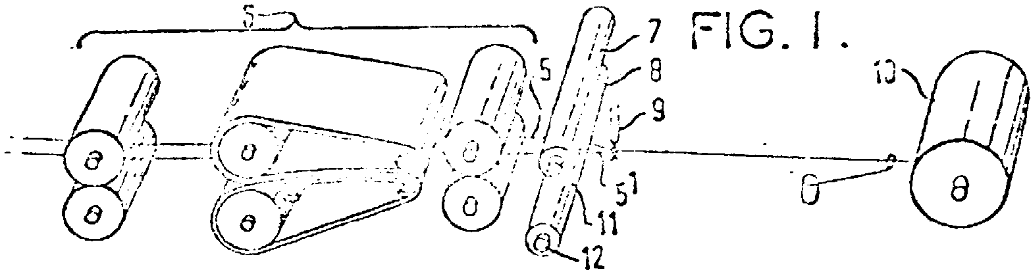


FIG. 1.

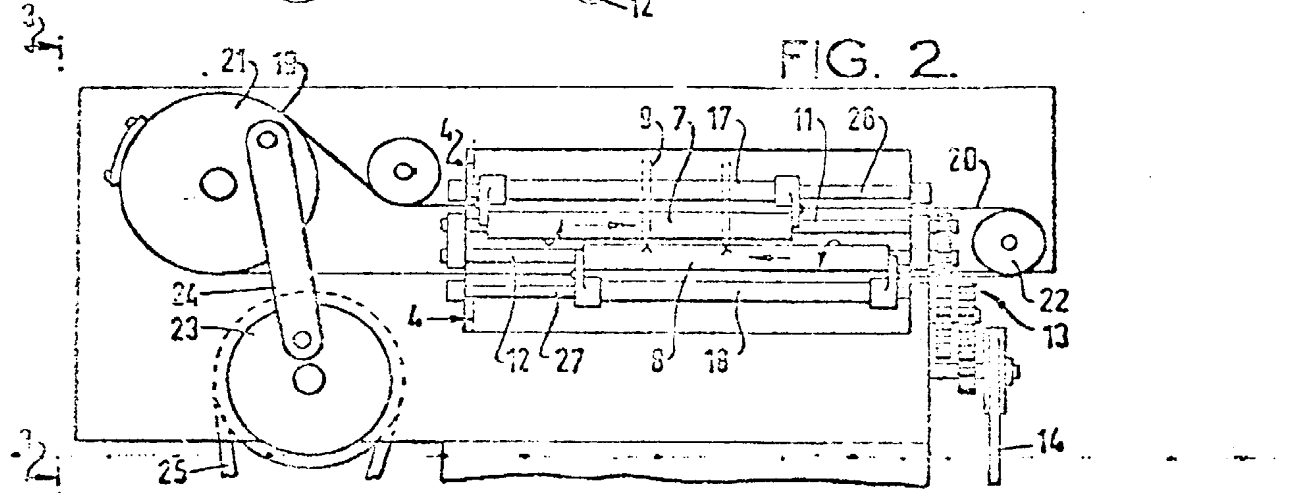


FIG. 2.

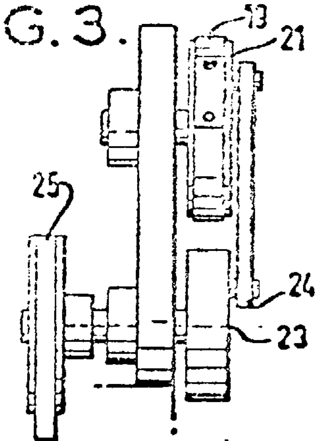


FIG. 3.

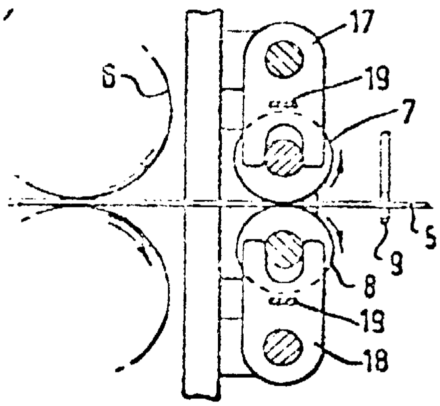


FIG. 4.

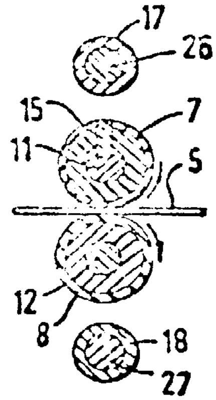


FIG. 6.

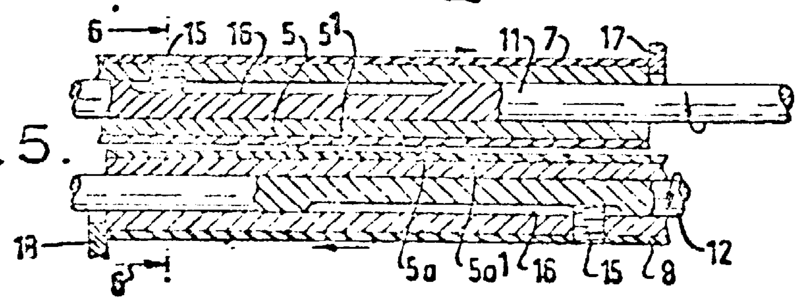


FIG. 5.

288664

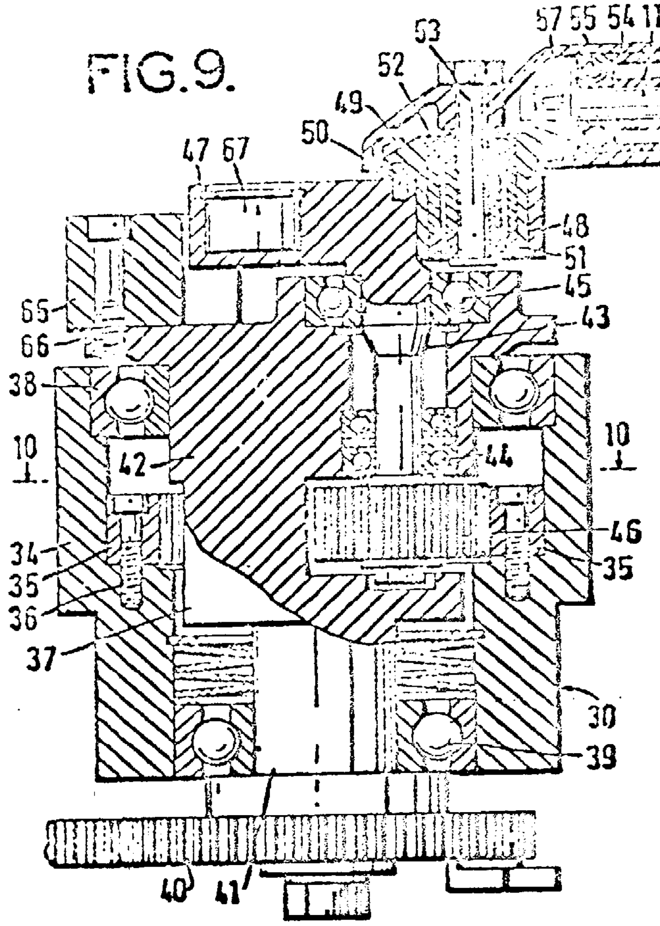


FIG.9.

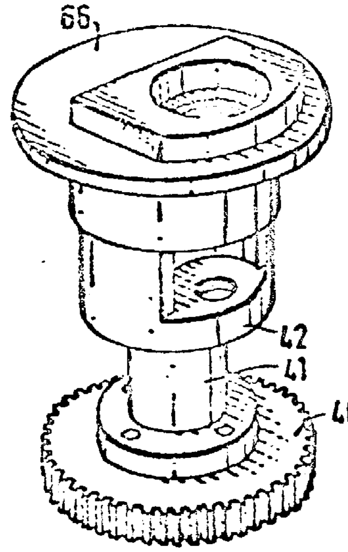


FIG.11.

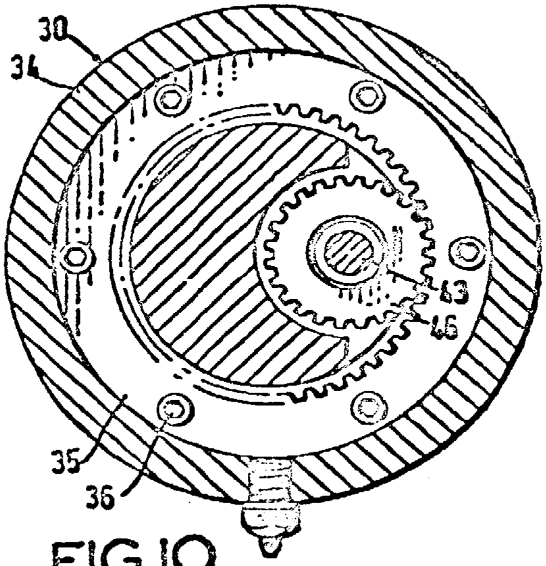


FIG.10.

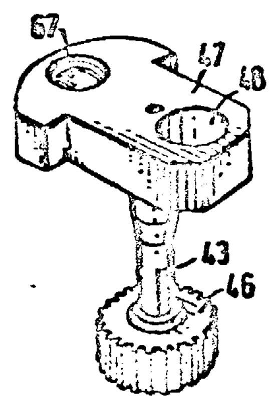


FIG.12.

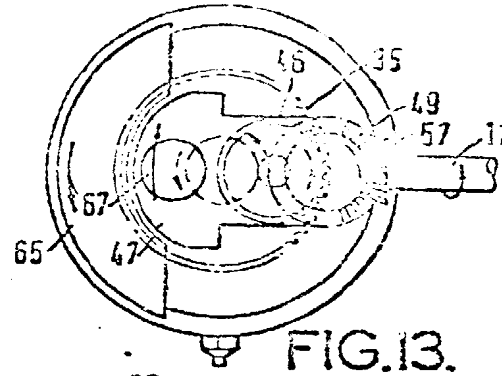


FIG.13.

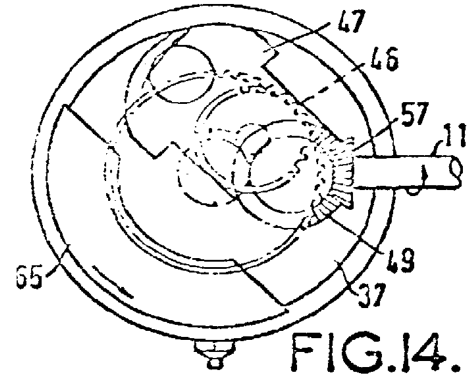


FIG.14.

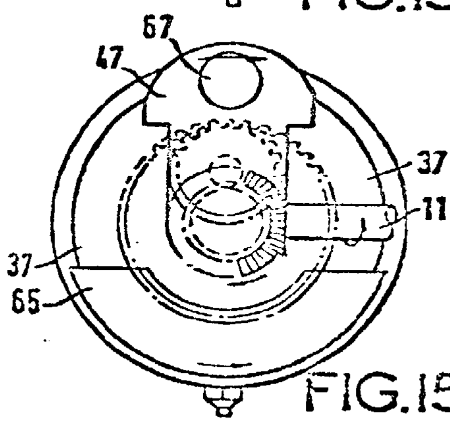


FIG.15.

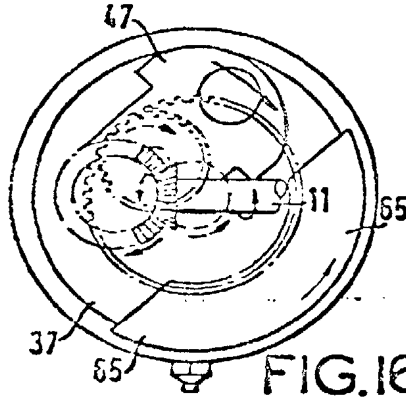


FIG.16.

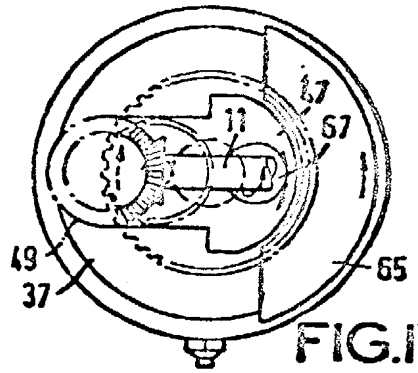


FIG.17.

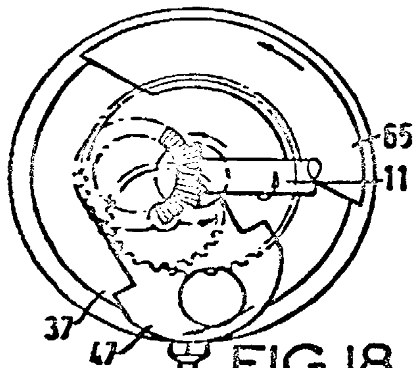


FIG.18.

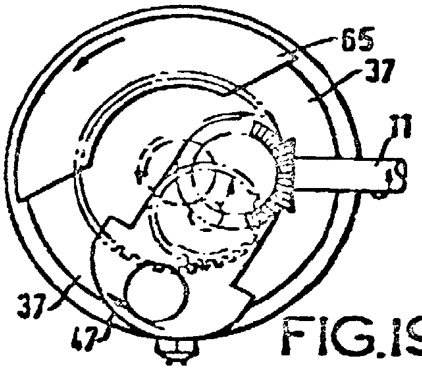
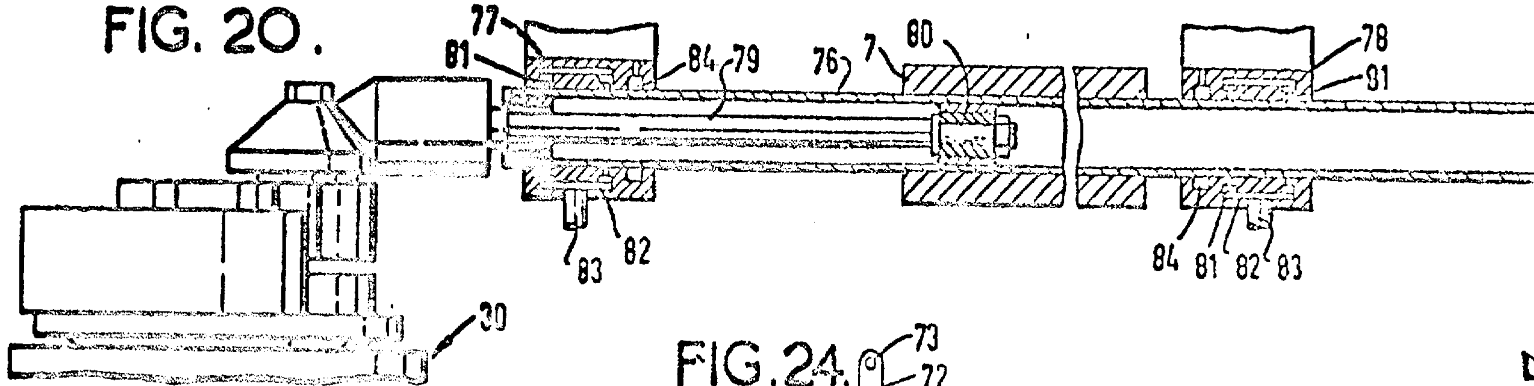


FIG.19.

288664

FIG. 20.



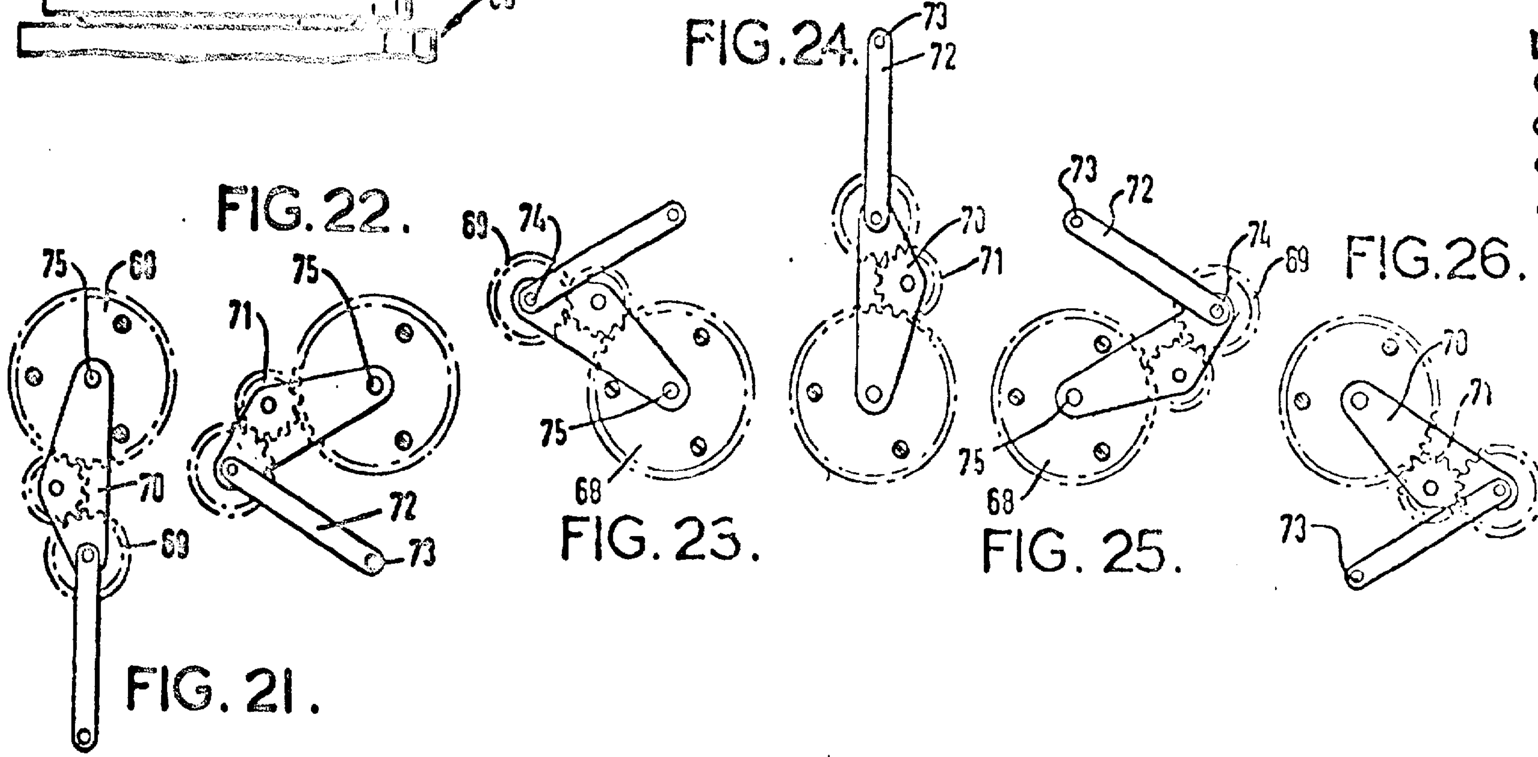


FIG. 21.

FIG. 22.

FIG. 23.

FIG. 24.

FIG. 25.

FIG. 26.